

Isobaric analog states in the $f_{7/2}$ and $g_{9/2}$ shells

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Previously, in a single- j -shell calculation ($j = g_{9/2}$), we obtained the excitation energy of the $J = 0^+$, $T = 2$ isobaric analog state in ^{96}Ag to be a bit below 1 MeV relative to the $J = 8^+$, $T = 1$ ground state. We here use binding energy data and Coulomb energy estimates to obtain this same excitation energy and to see if the two approaches are consistent.

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If there were no violation of charge independence, the binding energy of ^{96}Pd ground state ($J = 0^+$, $T = 2$) would be identical to the binding energy of the analog state, also $J = 0^+$, $T = 2$, in ^{96}Ag . But, since that is not the case in real life, the excitation energy of the $J = 0^+$, $T = 2$ state in ^{96}Ag is then given by

$$E^*(J = 0^+, T = 2) = BE(^{96}\text{Ag}) - BE(^{96}\text{Pd}) + V_C, \quad (1)$$

where the BE s are the binding energies and V_C includes all charge-independence violating effects. We here assume that V_C arises from the Coulomb interaction and use the formula of Anderson et al. [1]:

$$V_C = E_1 Z/A^{(1/3)} + E_2, \quad (2)$$

where $Z = (Z_1 + Z_2)/2$. Anderson et al. [1] list four sets of values of E_1 and E_2 . We here use the average values $E_1 = 1.441$ MeV and $E_2 = -1.06$ MeV.

We show in Table I results for various nuclei, some for which the excitation energy of the analog state is known and some for which it is not. The binding energy differences are taken from Ref. [2]

The fact that the analog state and Coulomb arguments work well in known cases gives us confidence that we can use these for the unknown case of ^{96}Ag . Turning things around, if the isobaric analog state were found, then we might have a better constraint on what the binding energy is.

We can compare the results of the calculated excitation energies with selected calculations in the literature. For ^{44}Sc and ^{46}Sc , single- j -shell results ($f_{7/2}$) [3] are respectively 3.047 and 4.949 MeV, as compared with Table I's results of 2.873 and 5.024 MeV. For ^{96}Ag single- j -shell results [4] are 0.900 MeV with INTd and 0.842 MeV with the CCGI interaction [4, 5]. These are lower than the value in Table I of 1.142 MeV. There are also large scale calculations with the jj44b [6] interaction for ^{96}Ag —the result is 1.996 MeV, significantly larger than the calculated value. In ^{94}Rh the jj44b interaction yields 3.052 MeV, larger than the Table I's value of 2.657 MeV. The INTd result is too low at 1.990 MeV.

In view of the differing results of shell model calculations, it would be of great interest to measure the excitation energies of isobaric analog states in the $g_{9/2}$ region. We hope that this work will encourage experimentalists to look

Table I: Excitation energies of isobaric analog states in MeV.

NUCLEUS	Binding Energy Difference	Coulomb Energy	Excitation Energy	Single j	Large space	Experiment
^{44}Sc	4.435	7.308	2.873	3.047 ^a	3.418 ^b	2.779
^{46}Sc	2.160	7.184	5.024	4.949 ^a	5.022 ^b	5.022
^{52}Mn	5.494	8.399	2.905	2.774 ^c		2.926
^{60}Cu	6.910	9.430	2.520			2.536
^{94}Rh	10.386	13.043	2.657	1.990 ^c	3.052 ^d	
				2.048 ^e		
^{96}Ag	12.432	13.574	1.142	0.900 ^c	1.996 ^d	
				0.842 ^e		

^aEscuderos, Zamick, Bayman (2005) [3].

^bGXPf1 interaction [8].

^cZamick and Escuderos (2012) [4].

^djj44b interaction [6].

^eCCGI interaction [4, 5].

not only for the surprisingly neglected $J = 0^+$ isobaric analog states in ^{94}Rh and ^{96}Ag , but also for other such states throughout this region.

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